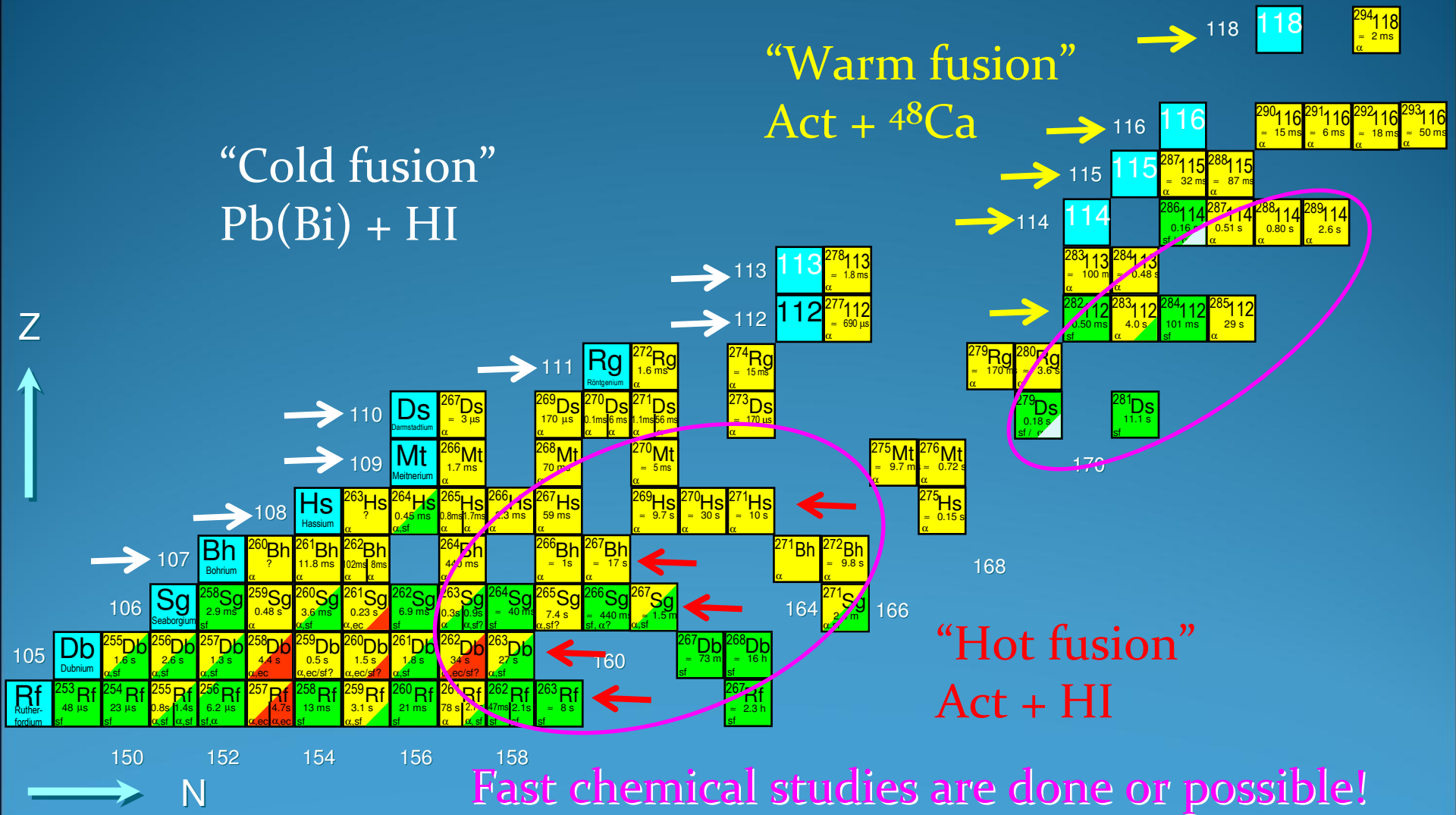
Next SHE (Chemistry) Experiments

Alexander Yakushev (TU Munich)

for SHE chemistry collaboration at TASCA

SHE for chemical studies



Fast chemical studies are done or possible!

Element 104 - Rf

Nuclear reactions leading to Rf isotopes, which can be used for chemical separations:

$^{244}Pu(^{22}Ne,5n)^{261}Rf$ (70 s)
$^{238}U(^{26}Mg,5n)^{259}Rf$ (3 s)
$^{208}Pb(^{50}Ti,1n)^{257}Rf$ (4 s)

New gas phase chemistry with hexafluor-acetylacetonat complexes of Rf
Test experiments with Zr and Hf have been performed

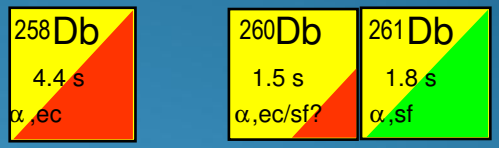
Liquid phase chemistry: ion exchange or extraction

Chemical separation can be used for decay spectroscopy studies under background-free conditions

Element 105 - Db

Nuclear reactions leading to Db isotopes, which can be used for chemical separations:

$^{243}Am(^{22}Ne;4,5n)^{260,261}Db$ (1.5 s; 1.8 s)
$^{238}U(^{27}Al;4,5n)^{260,261}Db$ (1.5 s; 1.8 s)
$^{209}Bi(^{50}Ti,1n)^{258}Db$ (4 s)



Liquid-liquid extraction with SISAK
Gas phase chemistry with halides – detection in ROMA

Element 106 - Sg

Nuclear reactions leading to Sg isotopes, which can be used for chemical separations:

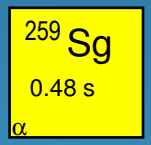
$^{248}Cm(^{22}Ne,5n)^{265}Sg$ (15 s)

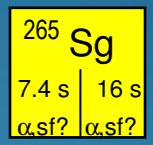
$^{244}Pu(^{26}Mg,5n)^{265}Sg$ (15 s)

$^{238}U(^{30}Si,5n)^{263}Sg$ (0.3/0.9 s)

$^{242}Pu(^{26}Mg,5n)^{263}Sg$ (0.3/0.9 s)

$^{208}Pb(^{52}Cr,1n)^{259}Sg$ (0.5 s)





New gas phase chemistry with hexacarbonyl complexes of Sg

Liquid phase chemistry: ion exchange or extraction

Chemical separation can be used for decay spectroscopy studies under background-free conditions

Element 107 - Bh

Nuclear reactions leading to Bh isotopes, which can be used for chemical separations:

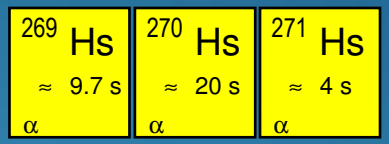
$^{243}Am(^{26}Mg,4n)^{265}Bh$ (new isotope, ~ 1 s)

New gas phase chemistry with (hydroxy) oxide of Bh
Liquid-liquid extraction with SISAK
Gas phase chemistry with halides – detection in ROMA

Element 108 - Hs

Nuclear reactions leading to Hs isotopes, which can be used for chemical separations:

$^{248}Cm(^{26}Mg,3\text{-}5n)^{269\text{-}271}Hs$ (4-20 s)



$^{232}Th(^{48}Ca,3\text{-}5n)^{275\text{-}277}Ds \rightarrow (-\alpha)\ ^{271\text{-}273}Hs$ (new isotopes)

Electro-deposition of Hs on noble metals (ELCH)

Test experiments with Os have been performed

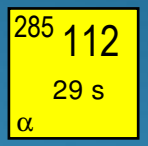
Liquid phase chemistry: ion exchange or extraction

Chemical separation can be used for search for new isotopes and for decay spectroscopy studies under background-free conditions

Element 112 – (Cn)

Nuclear reactions leading to E112 isotopes, which can be used for chemical separations:

$^{238}U(^{48}Ca,3n)^{283}112$ (4 s)



$^{242,244}Pu(^{48}Ca,3n)^{287,289}114 \rightarrow (-\alpha)^{283,285}112$ (4 s, 30 s)

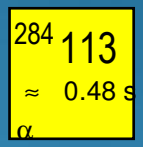
Comparative studies of E112 adsorption on metal surfaces and on an inert surface

Chemical separation can be used for decay spectroscopy studies under background-free conditions

Element 113

Nuclear reactions leading to E113 isotopes, which can be used for chemical separations:

$^{243}Am(^{48}Ca,3n)^{288}115 \rightarrow (-\alpha)^{284}113$ (0.5 s)



First chemical characterization: measurement of the volatility in the elemental state

Element 114

Nuclear reactions leading to E114 isotopes, which can be used for chemical separations:

$^{242}Pu(^{48}Ca,3n)^{287}114$ (0.5 s)

$^{244}Pu(^{48}Ca, 3\text{-}4n)^{288,289}114$ (0.8 s, 2.6 s)

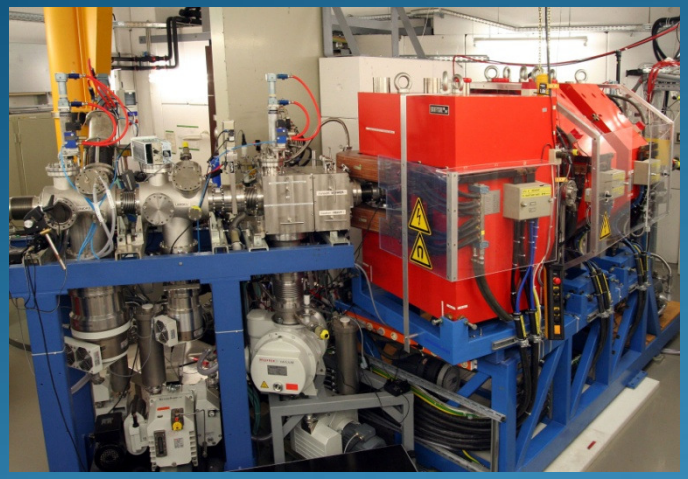
Comparative studies of E112 and E114 adsorption on metal surfaces and on an inert surface

Chemical separation can be used for decay spectroscopy studies under background-free conditions

Targets for SHE production

^{208}Pb	large target wheel available
^{209}Bi	large target wheel available
^{238}U	large target wheel available
^{242}Pu	target available?
^{244}Pu	small wheel available
^{243}Am	small/large target available
^{232}Th	large wheel available

Chemical apparatus



TASCA is used as preseparator

+

COMPACT or COLD for gas phase chemistry (~ 1 s)
ELCH for electrochemistry (~ 10 s)
SISAK for liquid-liquid extractions (~ 4 s)
ARCA for ion exchange chromatography (~ 30 s)

using gas (aerosol) jet transport

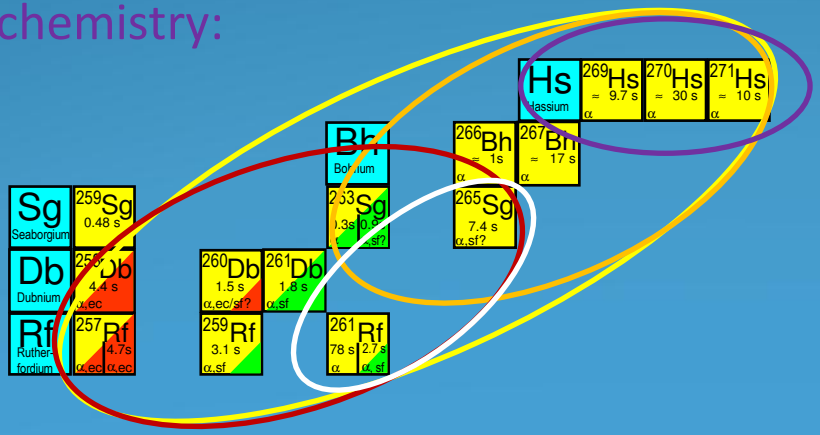
Chemical separation thechniques

Liquid phase chemistry

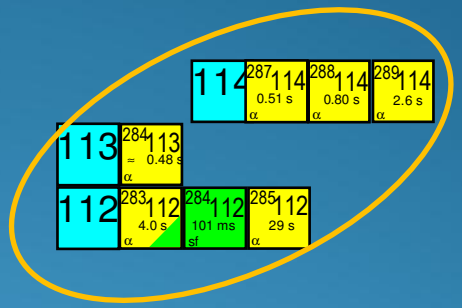
Liquid-liquid extraction:
SISAK, MicroSISAK

Ion exchange chromatography:
ARCA

Electrochemistry:
ELCH



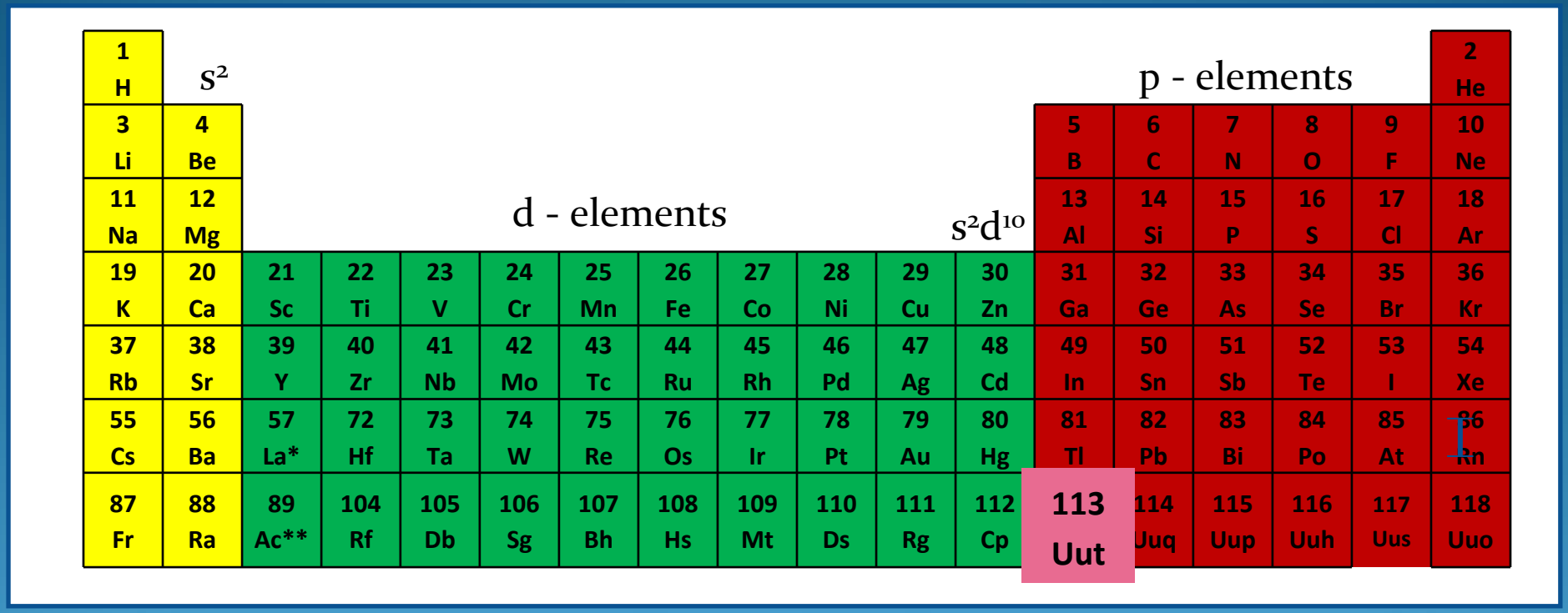
Gas phase chemistry



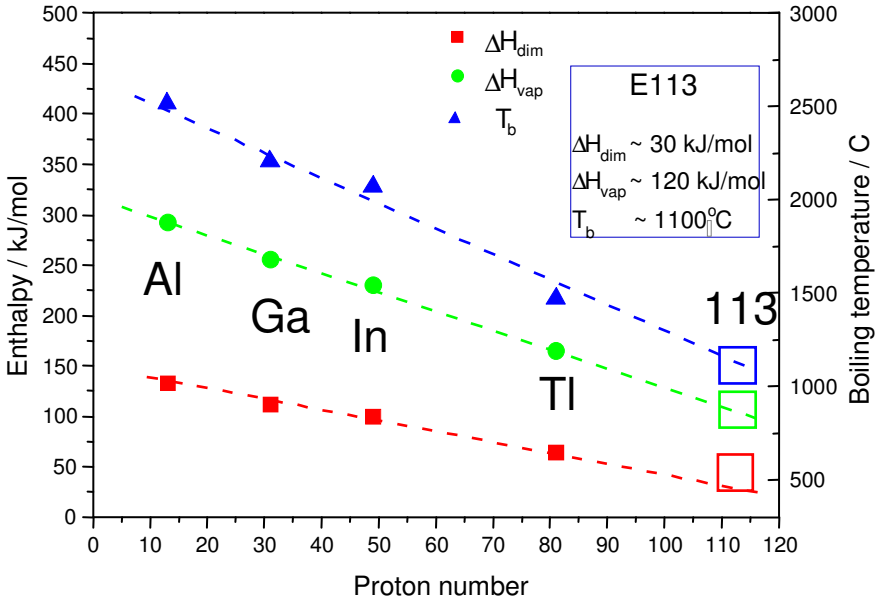
Thermochromatography:
COLD, COMPACT..

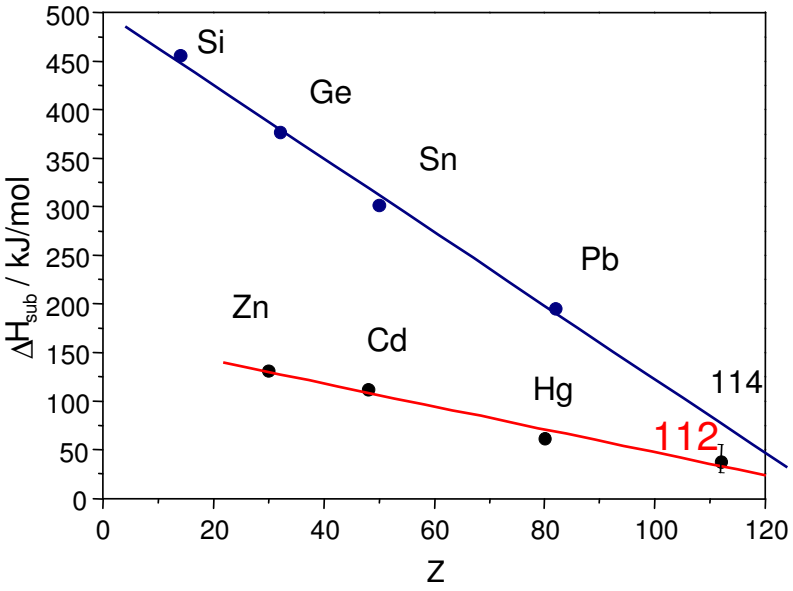
Isothermal chromatography:
OLGA-like + ROMA

Is element 113 a volatile metal?



Is element 113 a volatile metal?



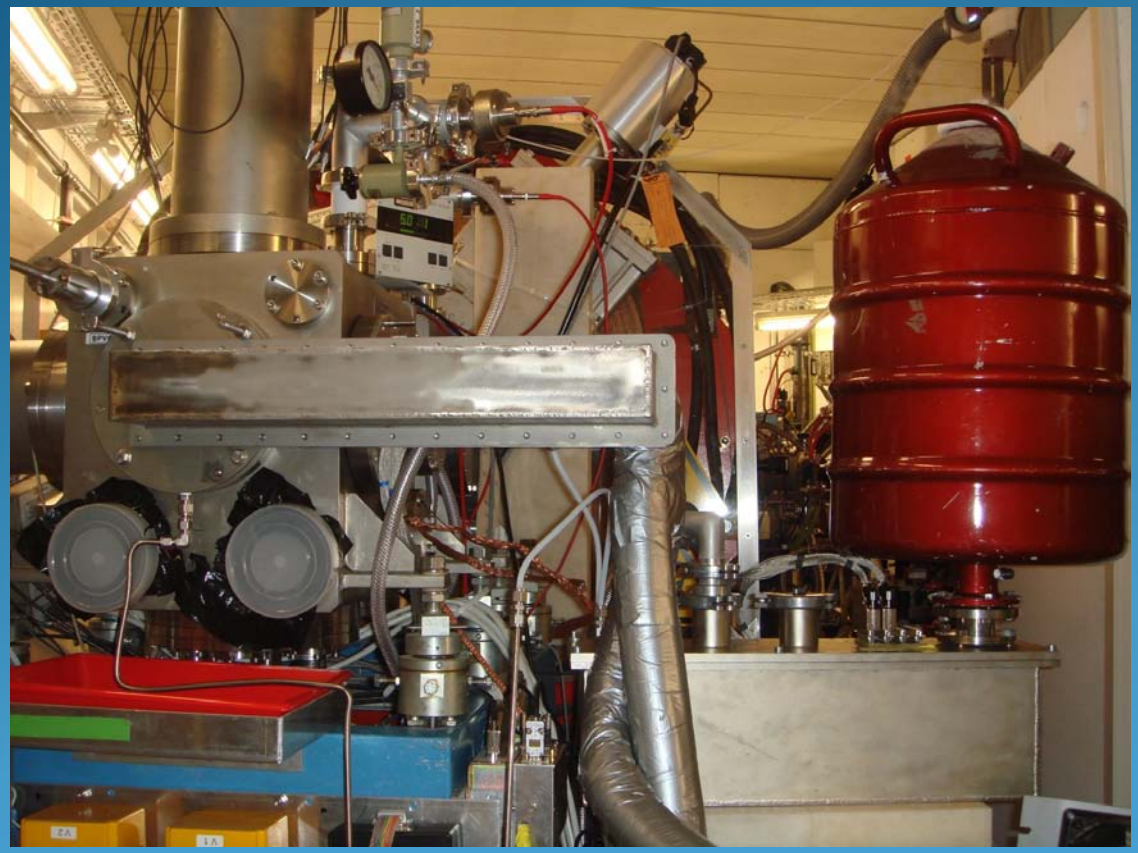


Next SHE chemistry experiment at TASCA (I)

$^{243}Am(^{48}Ca,3n)^{288}115 \rightarrow (-\alpha)^{284}113$ (0.5 s)

113
Uut

$^{284}113$
$\approx$ 0.48 s
α

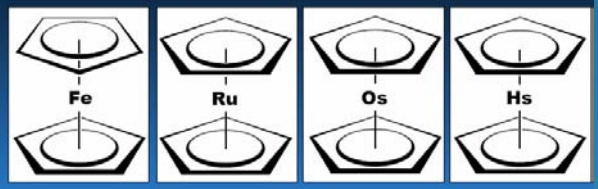


First E113 chemistry:

Study of volatility and adsorption on gold and/or an inert surface

Next SHE chemistry experiment at TASCA (II)

Hassocene – Science



-Group 8 metallocenes: 18 electrons

-$Ru(Cp)_2$ is the most stable metallocene!

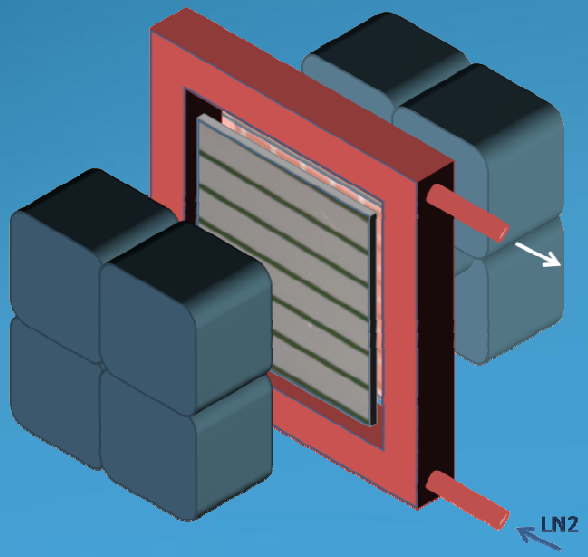
-Metal-ring bond strenght: Fe<Ru<Os

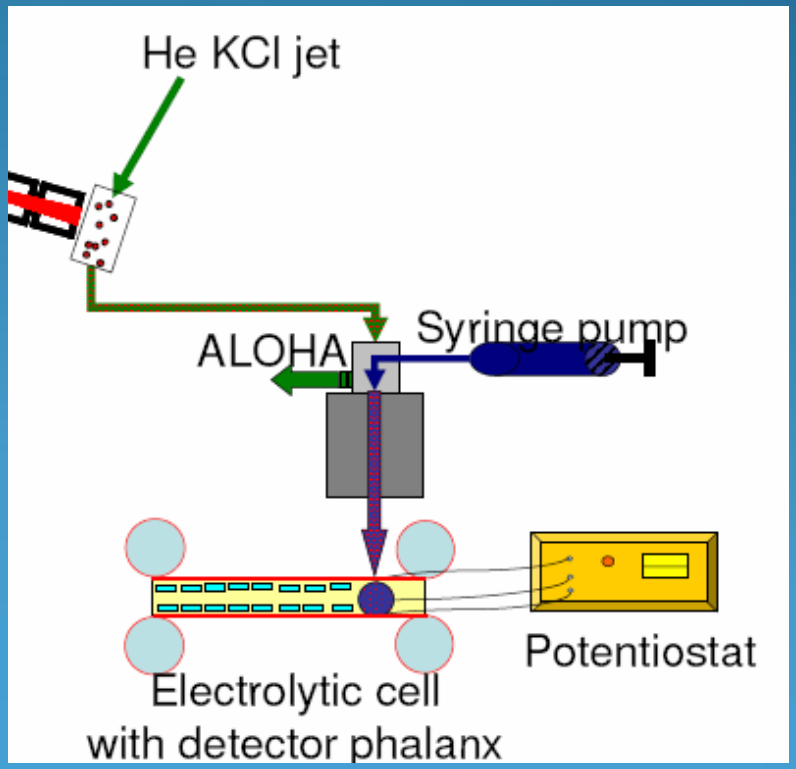
ΔH_{sub} [kJ/mol]	73.4±1.1	76-83	73-80	??

J.S. Chickos, W.E. Acree Jr., J. Phys. Chem. Ref. Data 31 (2002) 537

Hs chemistry and spectroscopy

^{269}Hs	^{270}Hs	^{271}Hs
≈ 9.7 s	≈ 20 s	≈ 4 s
α	α	α





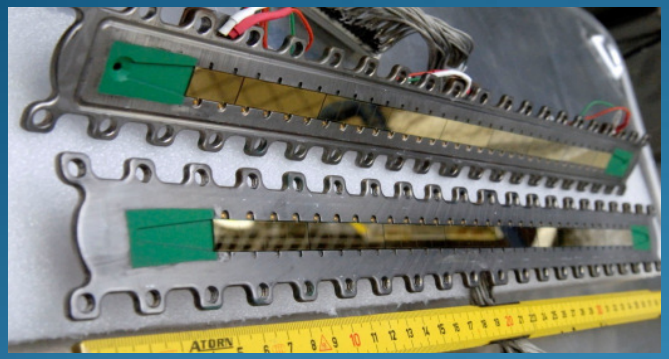
Problems in SHE (chemistry) at TASCA

- Low cross sections
- Short lifetime
- Relative low overall efficiency

We need high intense beam and new stable targets!

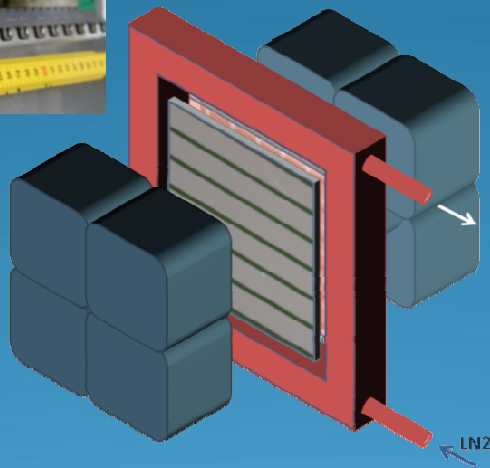
- Targets on large wheel (if possible)
- Enlarged beam spot on the target
- New developments on target backing material
- Permanent on-line target control

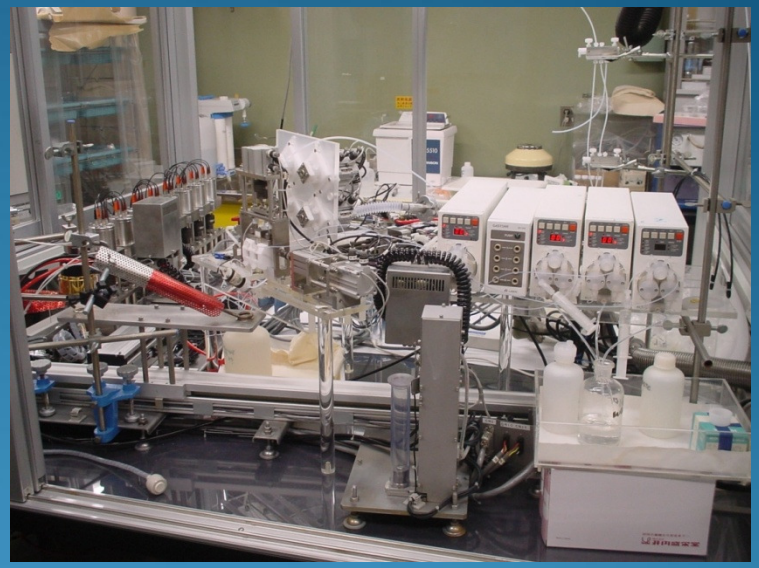
Citius, altius, fortius…



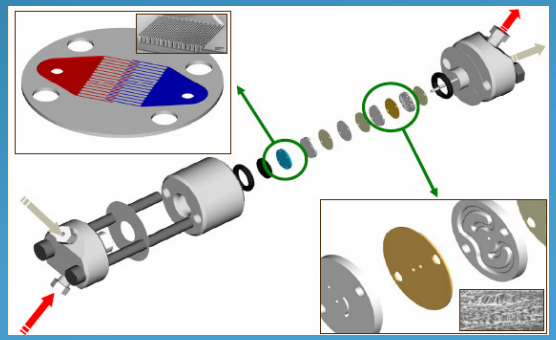
COMPACT

AlBeGaS

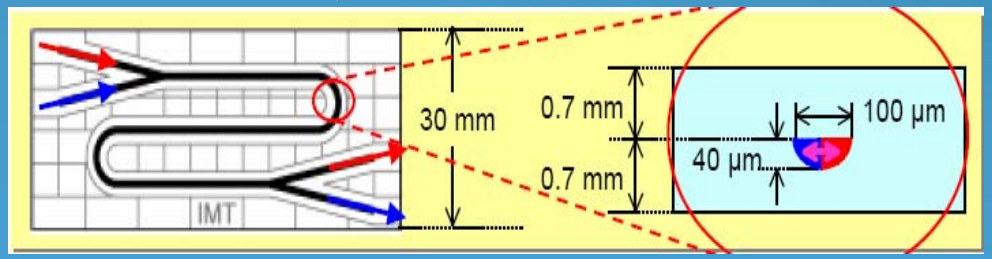




AIDA – new generation of ARCA



MicroSISAK



Microchip

…Who? What? When?

2010: Finish data analysis and publication
Prepare new targets (^{244}Pu, ^{243}Am, ^{248}Cm)
Finish tests for electrochemistry
Prepare a new detector AlBeGaS

If we have ^{243}Am target, we are ready for E113 chemistry

2011… Experiments on chemistry (SISAK, ELCH) and decay spectroscopy of Hs
Experiments on organometallic complexes of Rf, Sg and Hs

Thank you for your attention!